addition of 2, 4, 6, 8, 10, &c., which must be added alternately to each; 2, 6, 10, 14, &c. to b, b, and 4, 8, 12, 16, &c. to a, $a+1$; but the effect of this alternate addition of 2, 6, 10, &c. to b, b, by increasing one of them by 1 and diminishing the other, and of 4, 8, 12, &c. to a, $a+1$ by decreasing each time by 1 and increasing $a+1$ by 1, is to make the algebraic sum of the four roots at all times equal to 1, as is distinctly shown in the paper; and if $2a^2+2a+1+2b^2+c^2+c$ will represent any odd number, then $2a^2+2a+1+2b^2+c^2+c=2n+1$, deducting 1 and dividing by 2.

$a^2+a+b^2+\frac{c^2+c}{2}=n$, and as a^2+a+b^2 equals the sum of 2 triangular numbers and $\left(\frac{c^2+c}{2}\text{ is a triangular number}\right)$, therefore every number is composed of not exceeding three triangular numbers.

IV. "On the Structure and Affinities of *Eozoon Canadense.*" In a Letter to the President. By W. B. Carpenter, M.D., F.R.S. Received December 14, 1864.

I cannot doubt that your attention has been drawn to the discovery announced by Sir Charles Lyell in his Presidential Address at the late Meeting of the British Association, of large masses of a fossil organism referable to the Foraminiferous type, near the base of the Laurentian series of rocks in Canada. The geological position of this fossil (almost 40,000 feet beneath the base of the Silurian system) is scarcely more remarkable than its zoological relations; for there is found in it the evidence of a most extraordinary development of that Rhizopod type of animal life which at the present time presents itself only in forms of comparative insignificance —a development which enabled it to separate carbonate of lime from the ocean-waters in quantity sufficient to produce masses rivalling in bulk and solidity those of the stony corals of later epochs, and thus to furnish (as there seems good reason to believe) the materials of those calcareous strata which occur in the higher parts of the Laurentian series.

Although a detailed account of this discovery, including the results of the microscopic examinations into the structure of the fossil which have been made by Dr. Dawson and myself, has been already communicated to the Geological Society by Sir William E. Logan, I venture to believe that the Fellows of the Royal Society may be glad to be more directly made acquainted with my view of its relations to the types of Foraminifera which I have already described in the Philosophical Transactions.

The massive skeletons of the Rhizopod to which the name *Eozoon Canadense* has been given, seem to have extended themselves over the surface of submarine rocks, their base frequently reaching a diameter of 12 inches, and their thickness being usually from 4 to 6 inches. A vertical section of one of these masses exhibits a more or less regular alternation of calcareous and

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siliceous layers, these being most distinct in the basal portion. The specimens which the kindness of Sir William E. Logan has given me the opportunity of examining, are composed of carbonate of lime alternating with serpentine—the calcareous layers being formed by the original skeleton of the animal, whilst the serpentine has filled up the cavities once occupied by its sarcode-body. In other specimens the carbonate of lime is replaced by dolomite, and the serpentine by pyroxene, Loganite, or some other mineral of which silex is a principal constituent. The regular alternation of calcareous and siliceous layers which is characteristic of the basal portion of these masses, frequently gives place in the more superficial parts to a mutual interpenetration of these minerals, the green spots of the serpentine being scattered over the surface of the section, instead of being collected in continuous bands, so as to give it a granular instead of a striated aspect. This difference we shall find to depend upon a departure from the typical plan of growth, which often occurs (as in other Foraminifera) in the later stages—the minute chambers being no longer arranged in continuous tiers, but being piled together irregularly, in a manner resembling that in which the *cancelli* are disposed at the extremities of a long bone.

The minute structure of this organism may be determined by the microscopic examination either of thin transparent sections, or of portions which have been submitted to the action of dilute acid, so as to remove the calcareous shell, leaving only the siliceous *casts* of the chambers and other cavities originally occupied by the substance of the animal. Each of these modes of examination, as I have shown on a former occasion*, has its peculiar advantages; and the combination of both, here permitted by the peculiar mode in which the *Eozoon* has become fossilized, gives us a most complete representation not only of the skeleton of the animal, but of its soft sarcode-body, and its minute pseudopodial extensions as they existed during life. In well-preserved specimens of *Eozoon,* the shelly substance often retains its characters so distinctly, that the details of its structure can be even more satisfactorily made out than can those of most of the comparatively modern Nummulites. And even the hue of the original sarcode seems traceable in the canal-system; so exactly does its aspect, as shown in transparent sections, correspond with that of similar canals in recent specimens of *Polystomella, Calcarina,* &c. in which the sarcode-body has been dried.

This last circumstance appears to me to afford a remarkable confirmation of the opinion formed by Mr. Sterry Hunt upon mineralogical grounds—that the siliceous infiltration of the cavities of the *Eozoon* was the result of changes occurring *before* the decomposition of the animal. And the extraordinary completeness of this infiltration may be the result (as was suggested by Professor Milne-Edwards with regard to the infiltration of fossil bones and teeth, in the course of the discussion which took place last year on the Abbeville jaw) of the superiority of the process of

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* Memoir on *Polystomella* in Phil. Trans. for 1860, pp. 538, 540.

substitution, in which the animal matter is replaced (particle by particle) by some mineral substance, over that of mere *penetration.*

The *Eozoon* in its living state might be likened to an extensive range of building made up of successive tiers of chambers, the chambers of each tier for the most part communicating very freely with each other (like the secondary chambers of *Carpenteria*[*], so that the segments of the sarcodic layer which occupied them were intimately connected, as is shown by the continuity of their siliceous models. The proper walls of these chambers are everywhere formed of a pellucid vitreous shell-substance minutely perforated with parallel tubuli, so as exactly to correspond with that of *Nummulites, Cycloclypeus,* and *Operculina*[†]; and even these minute tubuli are so penetrated by siliceous infiltration, that when the calcareous shell has been removed by acid, the internal casts of their cavities remain in the form of most delicate needles, standing parallel to one another on the solid mould of the cavity of the chamber, over which they form a delicate filmy layer.

But, between the proper walls of the successive tiers of chambers, there usually intervene layers of very variable thickness, composed of a homogeneous shell-substance; and these layers represent the "intermediate" or "supplemental" skeleton which I have described in several of the larger Foraminifera, and which attains a peculiar development in *Calcarina*[‡]. And, as in *Calcarina* and other recent and fossil Foraminifera, this "intermediate skeleton" is traversed by a "canal-system"[§] that gave passage to the prolongations of the sarcode-body, by the agency of which the calcareous substance of this intermediate skeleton seems to have been deposited. The distribution of this canal-system, although often well displayed in transparent sections, is most beautifully shown (as in *Polystomella* [‖]) by the siliceous *casts* which are left after the solution of the shell, these casts being the exact models of the extensions of the sarcode-body that originally occupied its passages.

In those portions of the organism in which the chambers, instead of being regularly arranged in floors, are piled together in an "acervuline" manner, there is little trace either of "intermediate skeleton" or of "canal-system"; but the characteristic structure of their proper walls is still unmistakeably exhibited.

Whilst, therefore, I most fully accord with Dr. Dawson in referring the *Eozoon Canadense,* notwithstanding its massive dimensions and its zoophytic mode of growth, to the group of Foraminifera, I am led to regard its immediate affinity as being rather with the *Nummuline* than with the *Rotaline* series—that affinity being marked by the structure of the proper wall of the chambers, which, as I have elsewhere endeavoured to show[¶], is a character of primary importance in this group, the plan of growth and the mode of communication of the chambers being of secondary value, and the disposition of the "intermediate skeleton" and its "canal-system" being of yet lower account.

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[*] Phil. Trans. 1860, p. 566.

[†] Ibid. 1856, p. 558, and pl. xxxi. figs. 9 & 10.

[‡] Ibid. 1860, p. 553.

[§] Ibid. 1860, p. 554, plate xx. fig. 3.

[‖] Ibid. 1860, plate xviii. fig. 12.

[¶] Introduction to the Study of the Foraminifera, chap. iii.

I cannot refrain from stopping to draw your attention to the fact, that the organic structure and the zoological affinities of this body, which was at first supposed to be a product of purely physical operations, are thus determinable by the microscopic examination of an area no larger than a pin-hole—and that we are thus enabled to predicate the nature of the living action by which it was produced, at a geological epoch whose remoteness in *time* carries us even beyond the range of the imagination, with no less certainty than the astronomer can now, by the aid of "spectrum analysis," determine the chemical and physical constitution of bodies whose remoteness in *space* alike transcends our power to conceive.

The only objections which are likely to be raised by palæontologists to such a determination of the nature of *Eozoon,* would be suggested by its zoophytic mode of growth, and by its gigantic size. The first objection, however, is readily disposed of, since I have elsewhere shown [*] that a minute organism long ranked as zoophytic, and described by Lamarck under the designation *Millepora rubra,* is really but an aberrant form of the *Rotaline* family of FORAMINIFERA, its peculiarity consisting only in the mode of increase of its body, every segment of which has the characteristic structure of the *Rotalinæ*; and thus, so far from presenting a difficulty, the zoophytic character of *Eozoon* leads us to assign it a place in the *Nummuline* series exactly corresponding to that of *Polytrema* in the *Rotaline.* And the objection arising from the size and massiveness of *Eozoon* loses all its force when we bear in mind that the increase of FORAMINIFERA generally takes place by gemmation, and that the size which any individual may attain mainly depends (as in the Vegetable kingdom) upon the number of segments which bud *continuously* from the original stock, instead of detaching themselves to form independent organisms; so that there is no essential difference save that of continuity, between the largest mass of *Eozoon* and an equal mass made up of a multitude of *Nummulites.* Moreover there is other evidence that very early in the Palæozoic age the Foraminiferous type attained a development to which we have nothing comparable at any later epoch; for it has been shown by Mr. J. W. Salter [†] that the structure of the supposed coral of the Silurian series to which the name *Receptaculites* has been given, so closely corresponds with that which I have demonstrated in certain forms of the *Orbitolite* type [‡], as to leave no doubt of their intimate relationship, although the disks of *Receptaculites* sometimes attain a diameter of 12 inches, whilst that of the largest *Orbitolite* I have seen does not reach

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[*] Introduction to the Study of the Foraminifera, p. 235.

[†] Canadian Organic Remains. Decade i.

[‡] Phil. Trans. 1855.

$\frac{8}{10}$ths of an inch. And it is further remarkable in this instance, that the gigantic size attained by *Receptaculites* proceeds less from an extraordinary multiplication of segments, than from such an enormous development of the individual segments as naturally to suggest grave doubts of the character of this fossil, until the exactness of its structural conformity to its comparatively minute recent representative had been worked out.

In a private communication to myself, Dr. Dawson has expressed the belief that *Stromatopora* and several other reputed corals of the Palæozoic series will prove in reality to be gigantic Zoophytic Rhizopods, like *Eozoon* and *Receptaculites*; and I have little doubt that further inquiry will justify this anticipation. Should it prove correct, our ideas of the importance of the Rhizopod type in the earlier periods of geological history will undergo a vast extension; and many questions will arise in regard to its relations to those higher types which it would seem to have anticipated.

In the present state of our knowledge, however, or rather of our ignorance, I think it better to leave all such questions undiscussed, limiting myself to the special object of this communication—the application of my former Researches into the Minute Structure of the Foraminifera, to the determination of the nature and affinities of the oldest type of Organic Life yet known to the geologist.

December 22, 1864.

Dr. WILLIAM ALLEN MILLER, Treasurer and Vice-President, in the Chair.

The following communications were read :—

I. "On the Functions of the Fœtal Liver and Intestines." By Robert James Lee, B.A. Cantab., Fellow of the Cambridge Philosophical Society. Communicated by Robert Lee, M.D. Received November 1, 1864.

(Abstract.)

After some introductory remarks, the author observes that the intestines of the fœtus, between the fifth and ninth months of intra-uterine life, "contain a flocculent substance of orange-pink colour in the duodenal portion, a slimy green substance (the meconium) in their lower portion.

"The nature of the former was ascertained by Dr. Prout to be highly albuminous and nutritious. The nature of the latter, of which Dr. John Davy has given a complete analysis (Trans. Med. Chir. Soc.), is simply excrementitious. In the intermediate portion of the intestine the substance is of intermediate character; the more nutritive its property, the higher its position in the intestine."

He next points out that the mesenteric glands which belong to the